
Research Report
KTC-89-46

ANALYSIS OF EDGE DRAINS ON
WESTERN KENTUCKY PARKWAY
MILEPOST 83 TO MILEPOST 90

by

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EXECUTIVE SUMMARY

On August 14, 1989, the Kentucky Transportation Cabinet requested the Kentucky Transportation Center (KTC) to investigate an apparent drainage problem on the Western Kentucky Parkway. The area of concern was a rehabilitation project starting at Milepost 83 and ending at Milepost 90. The old PCC pavement was being broken and sealed and was being overlaid with approximately five inches of asphaltic concrete. Longitudinal edge drains (Hydraway brand) were installed in 1988, but the PCC pavement was not broken until July, 1989. Two inches of asphaltic concrete base were placed over the old broken pavement, and were used as a driving surface for a short period. During that time, several heavy rains occurred. After the rains, it was evident that a large amount of silt had been "pumped" up through the two inches of new base and deposited on the shoulder. The source of water and the silt was not immediately evident.

Field inspection and laboratory permeability tests indicated the drains were performing, but on several occasions, more water was seeping through the new asphalt overlay and the old broken slab than the drains had capacity to carry. This was causing water to backup in the drains and flow upwards through the new overlay and exit onto the shoulder.

It is recommended that the outlet headwalls be spaced no farther than 450 apart on two percent grades or greater, and 200 to 250 feet apart on grades less than two percent. It is also recommended that riding surface be a Class I or a Class A surface mixture. This will reduce the amount of water that seeps into the pavement.

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INTRODUCTION

On August 14, 1989, the Kentucky Transportation Cabinet requested the Kentucky Transportation Center (KTC) to investigate an apparent drainage problem on the Western Kentucky Parkway. The area of concern was a rehabilitation project starting at Milepost 83 and ending at Milepost 90. The old PCC pavement was being broken and seated and was being overlaid with approximately five inches of asphaltic concrete. Longitudinal edge drains (Hydraway brand) were installed in 1988, but the PCC pavement was not broken until July, 1989. Two inches of asphaltic concrete base were placed over the old broken pavement, and were used as a driving surface for a short period. During that time, several heavy rains occurred. After the rains, it was evident that a large amount of silt had been "pumped" up through the two inches of new base and deposited on the shoulder. The source of water and the silt was not immediately evident.

EDGE DRAIN INSPECTION

On August 15, 1989, personnel from the Kentucky Transportation Center drilled into the edge drains and photographed the interior of the drain panel with a boroscope. The drain panel had been partly crushed from the backfilling operation used during construction. It is estimated that approximately 30 to 40 percent

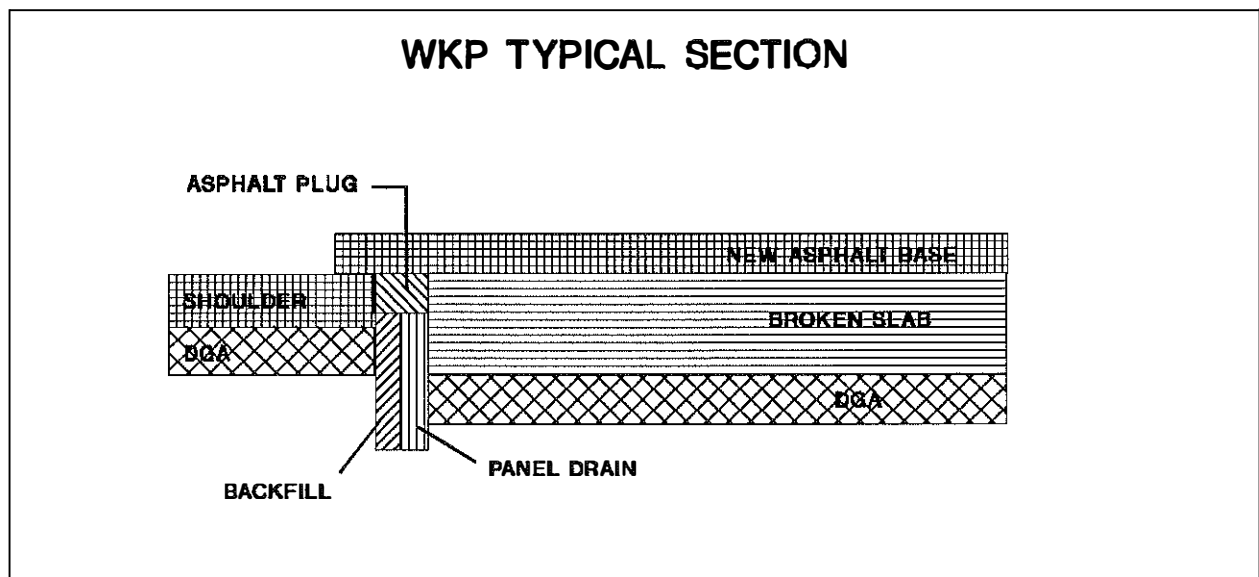


Figure 1. Typical Cross-Section for WKP at the Time Trench Was Opened.

of the internal volume of the drain had been reduced due to the crushing. However, the drains were still functioning at reduced capacity. ~~Although a large amount of grayish-white silt was~~ present at the headwalls, the drains appeared to be relatively free of silt deposits.

FIELD INSPECTION AND SAMPLING

On August 18, 1989, the pavement was trenched and sampled at two locations. The first site was at Milepost 84.5, and the second was at Milepost 84.0. A sketch (no scale) illustrating the typical cross section at both sites is shown in Figure 1. A trench approximately eight inches in width was cut from the centerline of the westbound lanes through the outside shoulder. The trench was cut approximately three inches into the subgrade. The edge drain panel was also severed when the trench was cut.

There was no free-flowing water in any portion of the pavement. However, droplets of water were trapped throughout the newly placed asphaltic concrete base. The cracks in the broken PCC slab were damp, but there appeared to be no free water in the broken slab. The dense-graded aggregate was damp, but it did not appear to be excessively wet. The subgrade appeared to be relatively dry with no free-flowing water. In short, there was little free water in any portion of the pavement section, except for the trapped water in the asphaltic base. The "uphill" end of the severed drainage panel drained water in a stream approximately 0.2-inch in diameter during the time the trenches remained open (approximately three hours).

Approximately 500 gallons of water were dumped onto the pavement at Site 2. A water truck was positioned approximately 100 feet upgrade from the open trench and the water was allowed to run out onto the asphaltic concrete surface from the spray bar on the back of the water truck. Some of the water ran down grade over the surface and into the trench. However, the "uphill" end of the severed panel drain began to emit a stream of water approximately two inches in diameter in less than five minutes from the time the water was released. This indicated that the newly placed asphaltic concrete base and the old broken slab were very porous and drained freely.

A four-inch perforated pipe was placed in the bottom of each trench and the trench was backfilled with sand and surfaced with an asphalt patch after the inspection was completed.

LABORATORY TESTING AND ANALYSES

Samples of the newly placed asphaltic concrete base course were collected at Sites 1 and 2. Constant-head permeability tests were performed on those samples in the laboratory. Three tests were conducted on each sample. Figure 2 shows the results of the average flow-versus-time curve for each sample.

The average coefficient of permeability, k , for the two asphaltic concrete base samples was calculated from the laboratory permeability tests, using the following equation:

$$k = QL / Aht \quad (1)$$

where

Q = quantity of flow (cm.³) - determined from Figure 2,
 L = length of specimen (cm.),
 A = area of specimen (cm.²),
 h = head loss across specimen (cm.), and
 t = time (sec.) - determined from Figure 2.

The average coefficient of permeability for the two samples was 3.5×10^{-4} centimeters per second.

To determine the flow of water through the pavement and into the drain, it is necessary to solve Equation 1 for Q , yielding:

$$Q = KAht/L. \quad (2)$$

In this particular case, the following values were used for the variables in Equation 2:

$k = 0.00035$ cm./sec.
 $A = 1.0$ square cm.
 $L = 5.08$ cm. (thickness of new asphalt overlay)
 $h = 5.08$ cm. (calculated from the top surface of the asphalt overlay to the bottom of the overlay)
 $t = 60$ sec.

Solving Equation 2 using these values yields the amount of water that would flow vertically through the pavement per unit of area per unit of time. In this case,

$$Q = 0.021 \text{ cm}^3/\text{minute}/\text{cm}^2 \text{ of pavement surface.}$$

Converting to English units:

or $Q = 0.125$ gallon/minute/linear foot of pavement,
 $Q = 1.0$ gallon/minute/8 linear feet of pavement.

Permeability Asphaltic Base Course

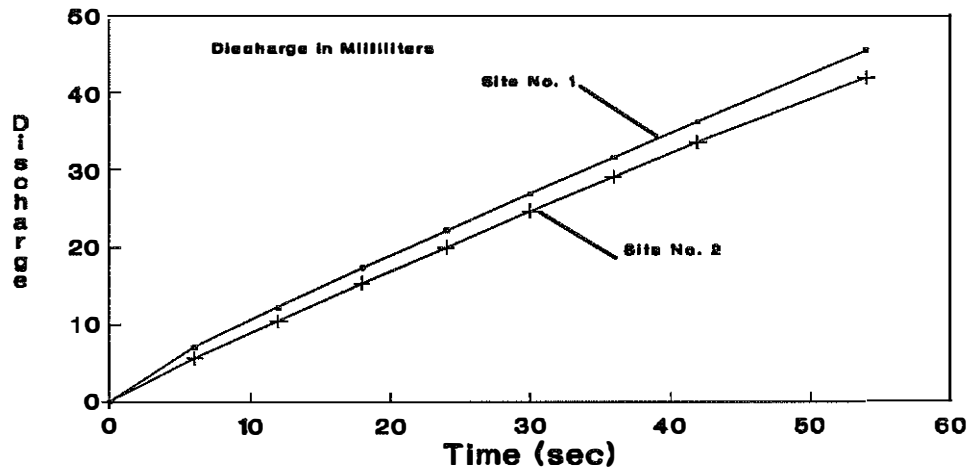


Figure 2. Flow Versus Time from Permeability Tests for Asphaltic Concrete Base (Sites 1 and 2).

The distance from the first trench to the next downgrade outlet headwall was approximately 700 feet. Therefore, in 700 linear feet $Q = 90$ gallons/minute.

The exact grade of the roadway at Sites 1 and 2 was not known by research personnel. However, visually it appeared to be approximately two percent. The manufacturer's published data indicate the capacity of the panel edge drain is approximately 15 gallons per minute at a two percent grade. At 700 feet between headwalls, the capacity of the drain was exceeded by more than six times. Reportedly, there are a number of headwalls on the project that are separated by distances of 2,200 feet. The flow from a section of this length would be 275 gallons per minute. This is 18 times greater than the drain capacity.

It is important to estimate the frequency and intensity of rainfall that would produce the quantities of flow discussed. The quantity calculated above from the permeability on the base course was:

$$Q = 0.021 \text{ cm}^3/\text{minute}.$$

This is approximately equal to 0.01 inch per minute or 0.60 inch per hour of rainfall intensity. Figure 3 shows the frequency of occurrence of this size rainfall for Evansville, Indiana (the

closest city for which data are available). A rainfall intensity of 0.60 inch per hour, and a duration of 90 minutes may occur one time each month. However, a rainfall of equal intensity but with a shorter duration could occur any number of times per month. Consequently, it appears the capacity of the drains could be exceeded several times each month.

Constant-head permeability tests were performed on six specimens of a Class I surface material. The average permeability was 9.54×10^{-5} centimeter per second. This is only 27 percent as permeable as the Class I base. Therefore, 30 linear feet of pavement having a Class I surface would be required to produce one gallon of water. Consequently, the headwalls could be placed at a maximum distance of 450 feet on a two percent grade without exceeding the capacity of the drains. At a lower grade, the headwalls should be placed closer.

CONCLUSIONS AND RECOMMENDATIONS

It appears the capacity of the drains was exceeded and allowed water to fill and overflow the drains. This excess water in the drains was forced upward through the asphalt plug covering the drain and through the two-inch overlay depositing concrete debris and limestone fines onto the surface of the shoulder.

When using panel edge drains, It is recommended that on two percent grades or greater that outlet headwalls be installed at least every 450 feet. On grades that are less than two percent, headwalls should be installed every 200 to 250 feet.

On break-and-seat projects, the surface should be paved with a Class I or a Class A surface mixture (dense mixture). This will reduce the amount of water infiltrating the pavement structure and ultimately entering the drain. Assuming the headwall distance recommendations listed above are followed, this should help prevent the drains from being overloaded.

INTENSITY – DURATION CURVES **EVANSVILLE, INDIANA**

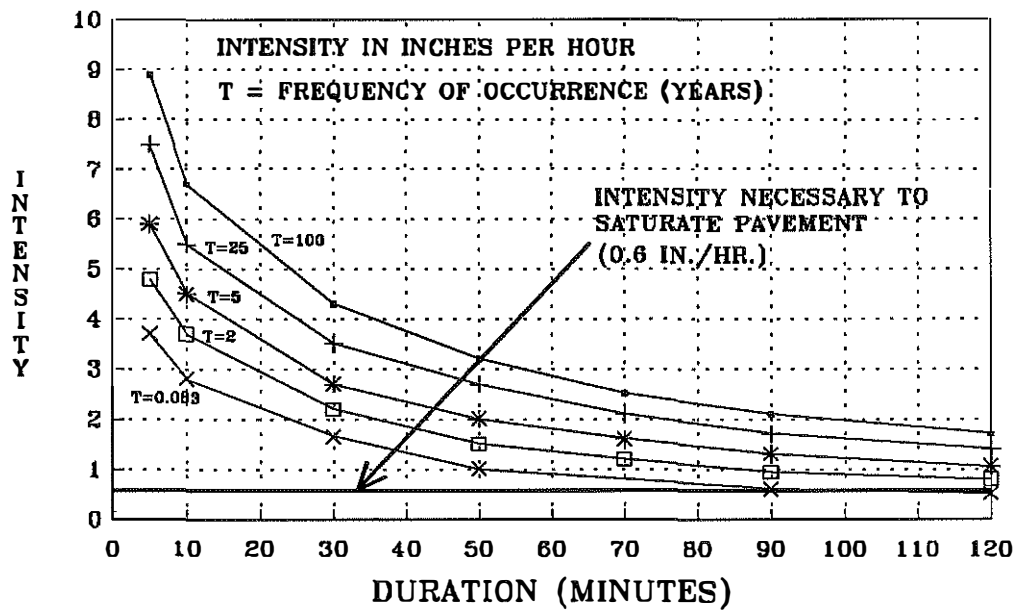


Figure 3. Rainfall-Intensity Curves (Evansville, Indiana)